Influence of Boron and Molybdenum on growth, yield and economics of Kabuli chickpea (*Cicer kabulium* L.)

ABSTRACT

A Field experiment titled "Influence of Boron and Molybdenum on growth, yield and economics of Kabuli chickpea (Cicer kabulium L.)" was conducted during *Rabi* 2022-2023 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil of experimental plot was sandy loam in texture, nearly neutral in soil reaction (pH 7.4), low in organic carbon (0.58%), available N (225 kg/ha), available P (32.30 kg/ha) and available K (350 kg/ha). The experiment was laid out in Randomized Block Design with ten treatments each replicated thrice. The result showed that growth parameters of Kabuli Chickpea viz., Higher plant height (68.49 cm), dry weight (24.34 g), number of nodules per plant (41.03) and the yield attributes namely pods per plant (14.29), seeds per pod (2.00), seed yield (3.29 t/ha), stover yield (3.36 t/ha) and harvest index (43.80%) were recorded significantly higher with application of treatment 9 Boron 2 kg/ha + Molybdenum 1.5 kg/ha. The higher net returns (122,782 INR/ha), gross return (165,977 INR/ha) and B:C ratio (2.84) was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

Key words: *Kabuli Chickpea, Boron, Molybdenum, Growth and Yield.*

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INTRODUCTION

"Chickpea, scientifically known as Cicer arietinum, is a versatile legume cultivated worldwide. India holds a prominent position in chickpea production and consumption. The country has a rich history of cultivating chickpeas, with major production areas in states like Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, and Andhra Pradesh. These regions provide favorable agro-climatic conditions for chickpea cultivation, such as well-drained soils and moderate temperatures. Chickpea contains 18-22 per cent protein, 52-70 per cent carbohydrate, 4-10 per cent fat and sufficient quantity of minerals, calcium, phosphorus, iron and vitamins" **(Pujitha *et al*.2022).**

"Its deep roots open up the soil, improving aeration, while leaf shedding increases the organic matter in the soil. It can fix nitrogen up to 25-30 kg/ha through symbiosis, thus reducing the dependency on chemical fertilizer. Therefore, chickpeas play an important role in improving the soil. Molybdenum (Mo) plays an important role in increasing chickpea yield through its effects on the plant itself and the symbiotic process of nitrogen fixation because Mo plays a direct role in nitrogen fixation in legumes". (Roy et al. 2006). "Mo is the key to nitrogen fixation by legumes" (Meagher et al. 1991).

"The total molybdenum content of the soil ranges from 0.2 to 5.0 mg/kg" (Sims 2000).

"Molybdenum deficient chickpeas produce fewer and smaller flowers, and many flowers do not open or mature, resulting in reduced seed yield". (Ahlawat et al. 2007).

"Boron deficiency and excess can cause physical and physiological disorders in plants" (Kastori et al., 2008). "Symptoms of boron deficiency are weak roots, poor apical meristem development, poor leaf growth, decreased chlorophyll and photosynthetic ratio, problematic ion channels; high phenol and lignin concentrations and low yields" (Wang et al., 2015). It has been reported that boron application may increase the growth of chickpea, and boron deficiency may seriously affect chickpea production.

By combining B and Mo sources and applying them at appropriate times, farmers can enhance improve crop performance, and contribute to sustainable chickpea production systems.

MATERIALS AND METHODS

The experiment was conducted at during rabi 2022, at Crop Research Farm, Naini Agricultural Institute, SHUATS, Prayagraj. The experimental site of the study is geographically located at 25.28^{o}N latitude, 81.54^{o}E longitude and 98 m altitude above the mean sea level (MSL). The soil of the experimental field constituting a part of central Gangetic alluvium is neutral and deep. The soil was sandy loam in texture, organic carbon (0.58%) and available nitrogen (225 kg/ha), phosphorous (32.30 kg/ha) and low in potassium (350 kg/ha). The experiment was laid out in randomized block design with three replications comprising ten treatment *viz.*, T_1: Boron 1 kg/ha + Molybdenum 0.5 kg/ha, T_2: Boron 1 kg/ha + Molybdenum 1 kg/ha, T_3: Boron 1 kg/ha + Molybdenum 1.5 kg/ha, T_4: Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha, T_5: Boron 1.5 kg/ha + Molybdenum 1 kg/ha, T_6: Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha, T_7: Boron 2 kg/ha + Molybdenum 0.5 kg/ha, T_8: Boron 2 kg/ha + Molybdenum 1 kg/ha, T_9: Boron 2 kg/ha + Molybdenum 1.5 kg/ha and T_{10}: Control (RDF 20:60:60 NPK kg /ha). Dollar variety chickpea was used for sowing. Recommended nutrient dose 20:60:60 NPK kg/ha were applied in the plot through urea, single super phosphate (SSP) and muriate of potash (MOP), respectively at the time of sowing. All other recommended agronomic practices were followed and plant protection measures were adopted as per need. The plots were prepared with dimension of 3m × 3m and seeds were sown with a spacing of 30cm × 10cm. Irrigations were given uniformly and regularly to all plots as per requirement so as to prevent the crop from water stress at any stage.

The crop was completely harvested at physiological maturity stage and their post-harvest observations such as number of pods per plant, number of seeds per pod, test weight (g), seed yield (t/ha), stover yield (t/ha) and harvest index (%) were recorded. The data recorded for different characteristics were subjected to statistical analysis by adopting the method of analysis of variance (ANOVA) as described by **Gomez (1984).**

RESULTS AND DISCUSSIONS

Growth parameters

Table.1 Pertaining the details of Influence of Boron and Molybdenum on growth attributes of Kabuli Chickpea.

Plant height (cm)

Significantly higher plant height (68.49 cm) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha at 120 DAS. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (67.77cm) and Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (67.22 cm) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

This may be due to the presence of molybdenum,fixed nitrogen which increases vegetative growth and plant height. On the other hand, boron plays an important role in cell division, differentiation an d growth of plants. Our results were also supported by (Singh et al., 2012) who reported that contin uous planting was done using boron and molybdenum. Mo fertilization at 1.5 kg/ha is equivalent to plant height, nodulation, number of pods, dry matter yield and seed yield (Meera et al., 2015). and o thers. 2019)

Dry weight (g)

Significantly higher dry weight (24.34 g) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha at 120 DAS. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (23.40 g), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (23.39 g) and Boron 1.5 kg/ha + Molybdenum 1 kg/ha (23.12 g) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

Dry weight per plant increased at harvest time. Plants fertilized with boron had higher total dry matter yield (30.36 g) and boron fertilization of 3 kg/ha increased plant growth (Kumar 2022). Plant growth isaffected by molybdenum application; Plants fertilized with molybdenum have higher total dry matter during growth because foliar application of molybdenum can improve plant growth

(Bhanavase and Patil, 1994) and (Johansen et al., 2007). The increase in dry matter with the increase in molybdenum supply is due to the increase in the number of pods (including seeds) per plant, and also because, according to **(Ahlawat *et al*. 2007)**, there were more flowers produced.

Number of nodules/plant

At 120 DAS, significantly higher number of nodules/plant (2.80) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (2.44) was found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

The improvement in crop growth and nodulation due to Mo and B can be attributed to their important role in nodule synthesis and nitrogen fixation (Hoque et al. 20 21). Similar studies were also found by (Chakraborty 2009), who reported that molybdenum application responds well to increasing the number of nodules in legumes. In terms of boron, the number of nodules increases as the boron content increases. Foliar boron sprays increased the number of root nodules compared to the control. These findings are corroborated by (Hasnain et a l., 2011).

Crop growth rate (g/m^2/day)

During 100-120 DAS, significantly higher crop growth rate (8.26 g/m^2/day) was recorded in Boron 1.5 kg/ha + Molybdenum 1 kg/ha. However, Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (8.22 g/m^2/day), Boron 2 kg/ha + Molybdenum 1 kg/ha (6.50 g/m^2/day) and Boron 2 kg/ha + Molybdenum 1.5 kg/ha (6.04 g/m^2/day) were found statistically at par with Boron 1.5 kg/ha + Molybdenum 1 kg/ha.

B (10 kg/ha) + Mo (0.2%) application (0.25 g/plant/day) recorded the maximum CGR. The increase in CGR in B and Mo with application indicates improved stem development of the crop, resulting in higher seed yield (Karim and Fattah, 2007).

Yield attributes

Table. 2 and 3 Pertaining the details of Influence of Boron and Molybdenum on growth and yield of Kabuli chickpea.

Number of pods/plant:

Significantly higher number of pods/plant (14.29) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (14.12), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (13.63), Boron 1 kg/ha + Molybdenum 1.5 kg/ha (13.80) and Boron 1 kg/ha + Molybdenum 1 kg/ha (13.60) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

The reason for this may be the use of molybdenum, which increases production (Awomi et al., 20 11). These results were supported by (Khan et al., 2014) who reported that molybdenum applicati on increased pods/plant yield. (Rabani et al. 2005) also showed a positive effect of molybdenum and noted that molybdenum fertilization had a significant effect on pods/plants. Molybdenum app lication increased active nodules and nodule weight per plant in chickpea (Khan et al. 2020). Bor on works in reproductive tissues and controls flower shedding, thus increasing the number of pod s/plants. It is consistent with our findings (Singh et al.). 2014) listed improved pods/plants of mol ybdenum and boron.

Number of seeds/pod

Significantly higher number of seed/pod (2.00) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (1.80), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (1.87) and Boron 1.5 kg/ha + Molybdenum 1 kg/ha (1.67) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

Data analysis showed that molybdenum and boron had a significant effect on the number of see ds per pod. While maximum number of the pods were found at the Mo application rate of 0.6 kg/ha, the least number of pods was found in the plants without Mo. Our results are similar to those (Tahir et al. 2011), which explained that molybdenum fertilization improves bean seed. In the case of boron, higher seed yield per pod was used at 3.6 kg/ha, while lower seed yield was recorded in plants not treated with boron. This is because boron plays a role in seed sowing and can increase the number of seeds per pod, which may be responsible for increasing seed yield. This result is consistent with (Kushwaha 1999) and (Hossain et al. 2016) claiming that boron application increases the number of seeds per pod.

Seed index (g)

Significantly higher seed index (41.28 g) was recorded in Boron 2 kg/ha + Molybdenum 1.5

kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (40.83 g), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (41.12 g), Boron 1.5 kg/ha + Molybdenum 1 kg/ha (41.10 g), Boron 1 kg/ha + Molybdenum 1.5 kg/ha (40.89) and Boron 1 kg/ha + Molybdenum 1 kg/ha (40.58) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

This may be because molybdenum improves nitrogen fixation, leading to maximum utilization and more thousand seed weights. The use of boron has been found to be beneficial. Our results are consistent with the result (Bellaloui et al., 2013) showing that boron application increased 100 grain weight. These results are consistent with those of Kaisher et al. 2010).

Seed yield (t/ ha)

Significantly higher seed yield (3.29 t/ha) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (3.18 t/ha), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (3.16 t/ha) and Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (2.94 t/ha) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

The increase in yield may be due to the growth of plants due to the rhizobial activity of molybde num, which increases the vegetative growth of the crop. These results are consistent with (Khan et al., 2014). They reported that molybdenum increased crop yields compared to control. Boron plays an important role in chickpea seed yield as it increases chickpea yield by regulating phytohormone levels, photosynthetic activity and plant growth. Our results are similar to (Shil et al. 2007). (Mekkei 2019) concluded that the foliar application of zinc, boron and molybdenum produced more chickpea seeds. (Kobraee 2019) also reported similar findings.

Stover yield (t/ha)

Significantly higher haulm yield (3.36 t/ha) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (3.30 t/ha) was found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

(Sarker et al., 2000) show that the use of boron and molybdenum has a positive effect on straw yield. (Hoque et al., 2021) reported a significant change in straw yield due to the use of boron a nd molybdenum. BARI Chola-9 had the highest yields (3.45 t/ha) when B and Mo were applied to the crop by foliar spraying and seed preparation, respectively.

Harvest Index (%)

Significantly higher harvest index (43.80 %) was recorded in Boron 2 kg/ha + Molybdenum 1.5 kg/ha. However, Boron 2 kg/ha + Molybdenum 1 kg/ha (43.12 %), Boron 2 kg/ha + Molybdenum 0.5 kg/ha (39.27 %), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (43.92 %), Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha (42.60 %) and Boron 1 kg/ha + Molybdenum 0.5 kg/ha (38.92 %) were found statistically at par with Boron 2 kg/ha + Molybdenum 1.5 kg/ha.

(Mekkei 2019) reported an 8.2% increase in yield in B + Mo application compared to control. This is because the increase in seed yield is greater than the increase in biomass. In both seasons, the highest yield (23.6% and 24.1%) was observed in (B+Mo) application. Therefore, increasing the seed yield can increase the product index. These results are consistent with (Sarbandi and Madani 2014), (Ganga et al., 2014). 2014), (Rahman et al., 2017), (Nasar and Sha h, 2017) and (Kobaraee 2019) reported that molybdenum application increased the index (%) of chickpeas and lentils.

Gross return (INR/ha)

The higher gross return was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha (165,977 INR/ha).

Net returns (INR/ha)

The higher net return was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha (122,782 INR/ha).

Benefit cost ratio (B:C)

Higher B:C was recorded with application of Boron 2 kg/ha + Molybdenum 1.5 kg/ha (2.84), as compared to rest of the treatments.

Hence, boron 2 kg/ha + molybdenum 1.5 kg/ha is economically profitable. There was considerable increase in the net return and B:C ratio with foliar spraying of Mo and B.

CONCLUSION

From the observations, it was concluded that with the combination of Boron 2 kg/ha + Molybdenum 1.5 kg/ha in treatment no. 9 significantly recorded higher in all the growth and yield attributes namely, plant height, dry weight, pods per plant, seeds per pod, seed index, seed yield, pod yield and haulm yield. Also recorded higher net return and B.C ratio and therefore is a fitting practice for augmenting higher Kabuli chickpea yields for farmer.

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Table 1: Influence of Boron and Molybdenum on growth attributes of Kabuli Chickpea.

S. No.	Treatments	Plant height (cm)	Dry weight (g)	Nodules/plant	CGR (g/m^2/day)	RGR (g/g/day)
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	61.70	18.40	1.40	6.58	0.01206
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	65.40	18.87	1.80	4.48	0.00770
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	66.01	20.08	1.93	4.35	0.00696
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	62.80	18.34	1.40	4.63	0.00823
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	66.59	23.12	2.13	8.26	0.01210
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	67.22	23.39	2.30	8.22	0.01184
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	64.15	18.31	1.40	4.43	0.00786
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	67.77	23.40	2.44	6.50	0.00911
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	68.49	24.34	2.80	6.04	0.00806
10.	Control (RDF 20:60:60 NPK kg/ha)	61.11	17.68	0.80	4.41	0.00805
	F Tab (5%)	S	S	S	S	NS
	SEm (±)	0.50	0.47	0.13	0.81	0.001
	CD (p=0.05%)	1.40	1.33	0.37	2.26	-

Table 2:Influence of Boron and Molybdenum on yield attributes of Kabuli Chickpea.

S.No.	Treatments	Pods/plant	Seeds/pod	Seed index
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	12.20	1.20	39.38
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	13.60	1.33	40.58
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	13.80	1.33	40.89
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	12.33	1.13	39.56
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	13.44	1.67	41.10
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	13.63	1.87	41.12
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	12.67	1.40	39.72
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	14.12	1.80	40.83
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	14.29	2.00	41.28
10.	Control (RDF 20:60:60 NPK kg/ha)	11.68	1.00	37.46
	F-Test	S	S	S
	SEm (±)	0.28	0.16	0.40
	CD (p = 0.05)	0.80	0.47	1.11

Table 3: Influence of Boron and Molybdenum on yield attributes of Kabuli Chickpea.

S.No.	Treatments	Seed yield (t/ha)	Haulm yield (t/ha)	Harvest Index (%)
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	1.52	2.16	38.92
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	2.24	2.91	34.00
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	2.46	2.98	36.61
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	1.88	2.24	35.74
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	2.94	3.06	42.60
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	3.16	3.21	43.92
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	2.19	2.41	39.27
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	3.18	3.30	43.12
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	3.29	3.36	43.80
10.	Control (RDF 20:60:60 NPK kg/ha)	1.26	2.01	26.30
	F-Test	S	S	S
	SEm (±)	0.112	0.03	2.52
	CD (p = 0.05)	0.313	0.09	7.04

Table 4. Influence of Boron and Molybdenum on economics of Kabuli Chickpea

		Economics(INR)			
S.No.	**Treatments**	**Cost of Cultivation (INR/ha)**	**Gross return (INR/ha)**	**Net return (INR/ha)**	**B C ratio (%)**
1.	Boron 1 kg/ha + Molybdenum 0.5 kg/ha	41,645.00	76,760.00	35,115.00	0.84
2.	Boron 1 kg/ha + Molybdenum 1 kg/ha	42,295.00	113,120.00	70,825.00	1.67
3.	Boron 1 kg/ha + Molybdenum 1.5 kg/ha	42,945.00	124,230.00	81,285.00	1.89
4.	Boron 1.5 kg/ha + Molybdenum 0.5 kg/ha	41,770.00	94,940.00	53,170.00	1.27
5.	Boron 1.5 kg/ha + Molybdenum 1 kg/ha	42,420.00	148,470.00	106,050.00	2.50
6.	Boron 1.5 kg/ha + Molybdenum 1.5 kg/ha	43,070.00	159,580.00	116,510.00	2.70
7.	Boron 2 kg/ha + Molybdenum 0.5 kg/ha	41,894.00	110,595.00	68,701.00	1.63
8.	Boron 2 kg/ha + Molybdenum 1 kg/ha	42,545.00	160,759.00	118,213.00	2.77
9.	Boron 2 kg/ha + Molybdenum 1.5 kg/ha	43,195.00	**165,977**.00	**122,782**.00	**2.84**
10.	Control (RDF 20:60:60 NPK kg/ha)	40,745.00	63,630.00	22,885.00	0.56

*MSP (minimum support price) for chickpea= 5050 per quintal